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
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TECHNICAL REPORT No. 416-45

GERMAN "AT" MINE UNITS

SUMMARY

This report contains information on the German AT 1, AT 2 and AT 3 mine firing units. These units are combined acoustic-subsonic operated devices. AT 1 and AT 2 were designed for use in the LMB mine. AT 3 was designed for use in the TMB and TMC mines. All three of these units have been used operationally during the war.

September 1945

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## GERMAN "AT" MINE UNITS

### 1. Introduction.

(a) The Germans had attempted, since 1941, to produce a mine embodying subsonic firing, with only partial success. The result was the AT group of units, which includes the AT 1, AT 2 and AT 3 units. These units were formerly designated AA 1, AA 2 and AA 3 but AT is a more recent official German designation. It is reported that units of this type had been laid since 1942, but, until the war in Europe was over, only small parts of the units had been captured, and none had ever been recovered.

(b) AT 2 and AT 3 units have been captured and forwarded to U. S. Navy Ordnance Investigation Laboratory. None of the obsolete AT 1 units have been captured. Considerable documentary information is being forwarded separately; this report contains information derived entirely through preliminary screen of documents and interrogation of German prisoners of war.

### 2. General.

The German AT units are subsonic mine firing units for ground mines. The subsonic firing feature has some vertical directional characteristics, but, since the mines in which it is used are cylindrical, the Germans assumed that any position in which the mine might lie would not inhibit its proper operation. Each AT unit is fitted with a sonic acoustic triggering system designed to save the amplifier batteries of the subsonic component. The subsonic component is designed to operate in the range between 20 and 25 cps. The different units are likely to have slightly different resonances, with quite sharp resonance peaks, but this is considered a good operational property by the Germans.

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3. The Magnetophone.

A magnetophone ("klotz") is the detecting device for the subsonic component of the AT units. This device is sometimes known as a "doppelschwinger" or "double oscillator" by the Germans. A sectional drawing of the magnetophone appears in Fig. 1. The device is suspended from a supporting arm which is threaded into the minecase tail door on the axis of the mine. This supporting arm is fitted with a guard cylinder to prevent excessive motion on impact. The magnetophone is connected to the supporting arm by a type of bearing, such that it is free to rotate in a plane perpendicular to the axis of the mine. To prevent damage on laying, the magnetophone is held in a fixed position by an arm mounted on the tail door, and the magnetophone is released by the blowing of a fuse when the mine becomes armed. It is expected that the mine will lie horizontally or nearly so, and the weight of the magnetophone will cause it to swing to a hanging position.

4. Magnetophone Construction.

As shown in Fig. 1, the magnetophone consists of a magnet and the assembly for the coil. The magnet is cylindrical, and has two concentric poles with a small gap between. The magnetic field in this gap is 9000 gauss. The coil assembly is a group of zinc fittings bolted onto the gap end of the magnet. Inside the assembly, the coil is mounted on an aluminum block supported by two flat bronze springs. The coil is wound on a cylindrical paper form and held to it by shellac. Two springs are used to assure that motion of the coil between the magnet poles will be along the axis of the coil. A zinc strengthening strip is bolted on the bottom. When the magnetophone is held in fixed position before the release fuse blows, a pin fits through a hole in this strip to hold the aluminum coil-mounting block against its limit stop and prevent damage due to impact. The system is designed to have a resonance of 22 cps. The mass of the magnetophone and the length of the suspension are the principal factors in determining this frequency.

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5. AT 1.

The AT 1 unit was the first attempt to produce a subsonic firing device. In the AT 1, a simple sonic-acoustic triggering system started a clock which kept the subsonic system armed for a period of about 2 minutes. It was found that this unit was too easily swept and was especially subject to firing due to explosions. This may be seen in Fig. 4. The diagram showing the sound level changes caused by remote detonations shows that transmission through the ground reaches the mine approx.  $2\frac{1}{2}$  seconds (in the case shown) before transmission through the water. It would be possible, in the AT 1, for the ground wave to trigger the unit by actuation of the sonic system and the water-transmitted wave to fire the mine. This fault was eliminated by use of a different triggering system in AT 2. Therefore all existing AT 1 units, including those in the field, were converted to AT 2's, the modifications necessary for conversion lying primarily in the improvements in the acoustic triggering circuit.

6. Acoustic Triggering Circuit.

The modified type of acoustic triggering circuit as used in AT 2 and AT 3 appears in their circuit diagrams, Fig. 2 & 3. The normal cantilever-type carbon-button microphone is used in a transformer and rectifier circuit. The output signal current actuates relay Fu. Closure of its contact (fu) connects relay R<sub>1</sub> to the 96-volt battery through a 100 KOhm resistor. When contact (r<sub>1</sub>) closes, it turns on the heater potential to the three tubes of the subsonic amplifier. The resistor-condenser system in parallel with R<sub>1</sub> is designed to hold R<sub>1</sub> in the operated condition for 3-4 seconds if (fu) opens. This is designed to bridge any short interruptions in the triggering noise, but, at the same time, shut off again if the sound is other than a continuous one. This is an anti-sweep and anti-explosion feature. A continuous sound is necessary to keep the subsonic component of the unit alive, and it will remain alive until the sound stops. Detonation protection is also provided by transformer ST and its associated system. A detonation will produce a surge in the transformer which will operate

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Acoustic Triggering Circuit, (Cont'd).

relay P. Closure of contact (p) connects the time-delay system including relay R<sub>2</sub>. When R<sub>2</sub> is energized, contact (r<sub>2</sub>) opens, breaking the circuit from the firing (microphone) battery to the detonator. The time-delay circuit keeps R<sub>2</sub> energized for a period of about 3-4 seconds to allow the surge to pass.

7. AT 2 Amplifier - Subsonic.

The circuit of the AT 2 subsonic amplifier appears in Fig. 2. The amplifier consists of three vacuum-tubes. All are glass pentodes type RV 2,4 P 700. The magnetophone output is fed to a sharply-tuned transformer circuit. This circuit is tuned to 20-25 cps. The first amplifier tube may be tapped at three different points to determine the sensitivity of the unit. The output is condenser-coupled to the second stage. The output of the second stage is transformer-coupled to the third stage through a broadly-tuned transformer circuit. When the subsonic amplifier is switched on, contact (r<sub>1</sub>) breaks the connection between the grid of the third pentode with the ground through the 10 Ohm resistor. Thus, the grid potential of the third stage pentode will depend upon the output of the second stage. The output of the second stage is rectified and fed to a time-delay circuit with a total delay of approx. 2 sec. At the end of this delay, the grid of the third stage pentode becomes more positive and draws plate and screen grid current through the operation coil of relay R<sub>2</sub>. When contact (r<sub>2</sub>) closes, the detonator is fired.

8. AT 3 Amplifier - Subsonic.

The circuit of the AT 3 subsonic amplifier appears in Fig. 3. The amplifier consists of two vacuum-tubes. Both are metal pentodes type DF 11. The circuit is essentially similar to AT 2, except that the substitution of the metal tubes which have lower heater drain currents, increases the continuous drain life on the amplifier batteries from 50 hours (in AT 2) to 14 days. The AT 3

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AT 3 Amplifier - Subsonic. (Cont'd).

has no provision for setting sensitivity similar to that used in AT 2. As well, that third stage is omitted, and the output of the second stage is transformer-coupled to a full-wave rectifier and time-delay circuit which operates a relay ( $R_2$ ). Closure of contact ( $r_2$ ) puts the 96-volt battery across relay  $R_4$ . Closure of  $r_4$  fires the mine.

9. Comment.

Fig. 4 shows a German representation of various phases of AT mine characteristics. A sketch and a schematic representation of the magnetophone is shown. The relative response of the sonic microphone and the subsonic magnetophone is shown in the first chart. The second chart shows the subsonic effect at a point due to explosions at distance.

10. "Hell" Doppelschwinger.

When the AT units were in original development, part of the development was done by the firm Electroacoustic, Kiel, and part by Dr. Ing. Rudolf Hell, Berlin. The Electroacoustic (Elac) development was finally accepted, and is the type described in the preceding paragraphs. Dr. Hell's subsonic detecting device is of some interest, however. The magnetophone used in the AT units is the work of Dr. Gerloff of SVK, Kiel, and required a vacuum-tube amplifier. Dr. Hell, however, concentrated his efforts on producing a detecting device which would have high enough output to operate relay systems directly, as in the normal sonic acoustic systems. The experimental detector produced by Dr. Hell was a carbon-button device which Dr. Hell claims had a very sharp resonance peak at approx. 20.05 cps. This device, known as the "Hell Doppelschwinger", due to unsatisfactory results with an earlier device known as the "Einfacheschwinger", was constructed as shown in Fig. 5. Fig. 5 is modified slightly for clarity. There are two weights, each mounted on two suspension leaf springs, one above

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"Hell" Doppelschwinger. (Cont'd).

and one below. The upper weight and spring system is adjusted to be resonant to 20.0 cps. The lower weight and spring system is adjusted to be resonant to 20.1 cps. These two weight systems have resonance curves approximating those shown in Fig. 6. When the frequency is lower than the resonant frequency of the weight system, the weights oscillate together with the mass of the mine-case to which the detector is fixed. When the frequency is higher than the resonant frequency of the weight system, the weights oscillate approx.  $180^\circ$  out of phase with the mine-case. When the frequency lies between 20.0 and 20.1 cps, the two weight systems are  $180^\circ$  apart in phase. A carbon-button microphone element is connected to the two weight systems, and measures the relative motion between them. Thus, the output of the carbon-button reaches a peak when the frequency lies half-way between the resonant frequencies of the two systems (20.05 cps). The earlier type ("Einfacheschwinger") made use of only one resonant weight system and the other part of the carbon button was connected to a fixed part of the assembly. In this system the movement of the one system only is measured and there is no phasing effect. The "Einfacheschwinger" had a high subsonic output but its response was too broad to be desirable for use in an AT mine.

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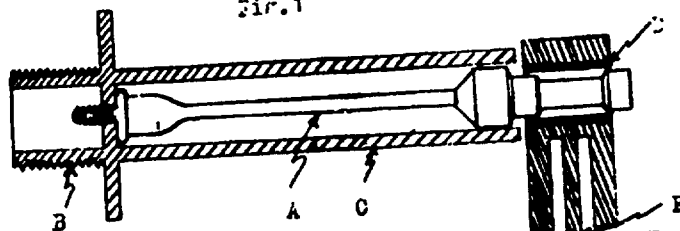
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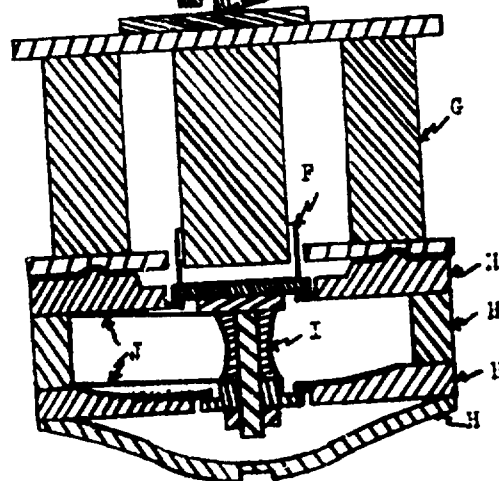
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Fig. 1



# Magnetophone for AT Units

- A = Suspension Arm
- B = Threads for Mounting
- C = Suspension Arm Guard
- D = Magnetophone Bearing
- E = Suspensor Spring
- F = Coil
- G = Magnet
- H = Zinc Coil Assembly Pieces
- I = Coil Block
- J = Bronze Leaf Springs

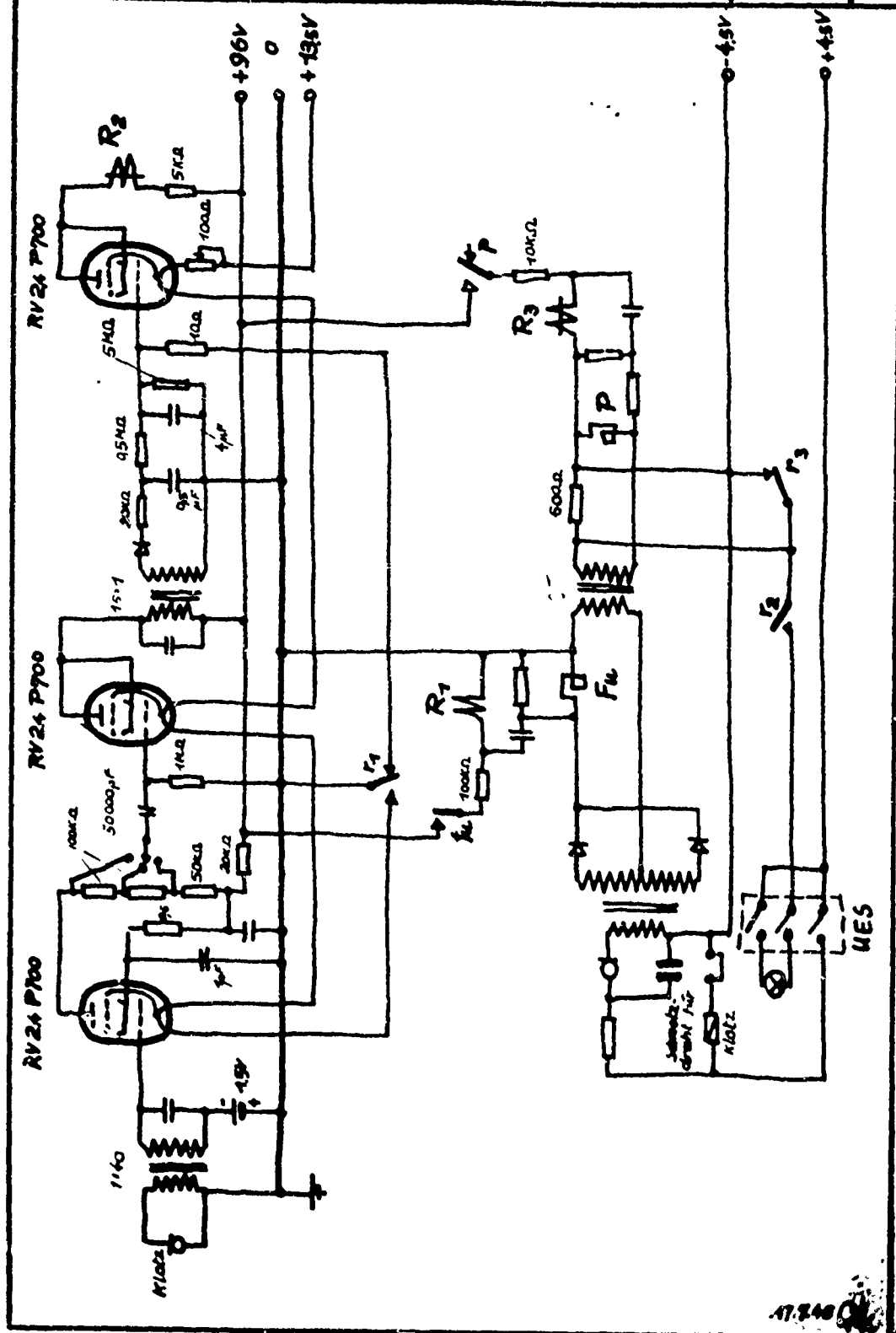


# Schaltbild AT2

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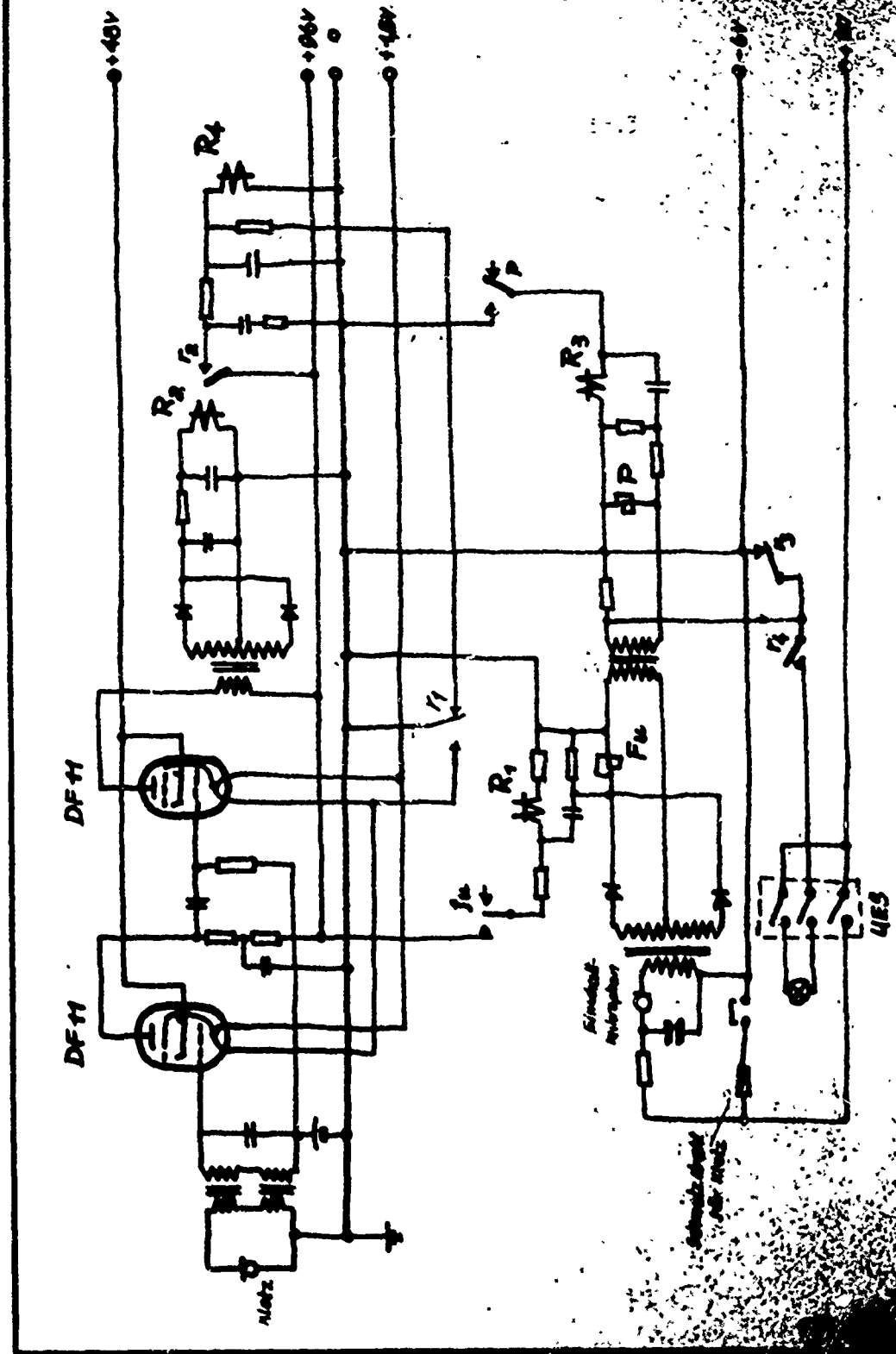
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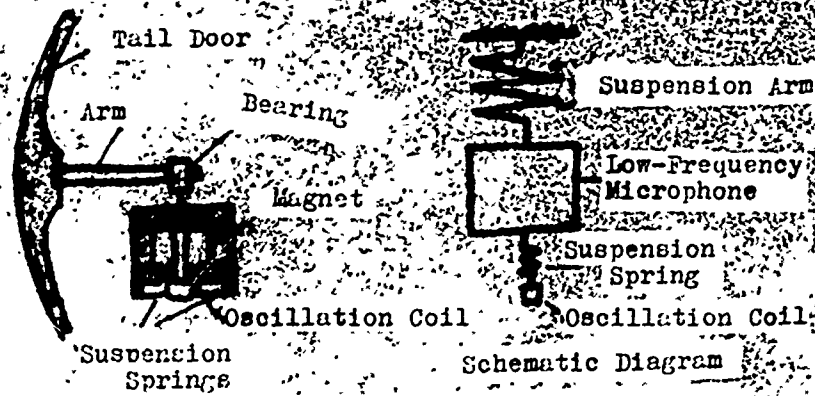


AT 240

# Schaltbild AT3.

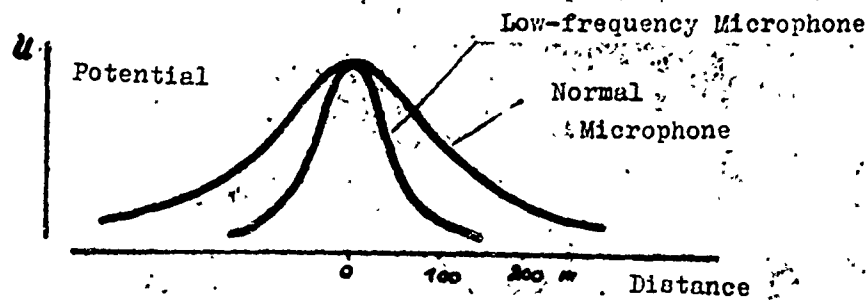


# PRINCIPLES OF SUB-SONIC FIRING



Principle and Construction of the Magnetophone

Fig. 4



SHIP'S TRANSIT

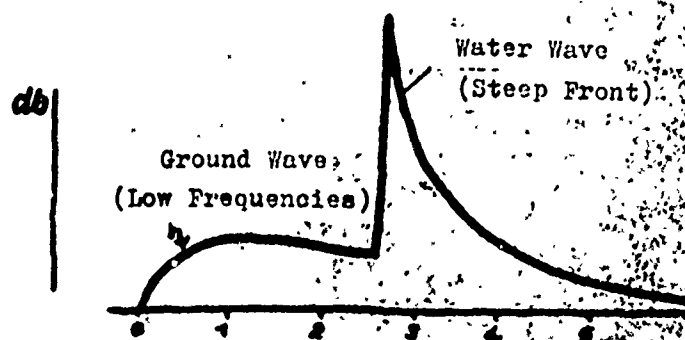
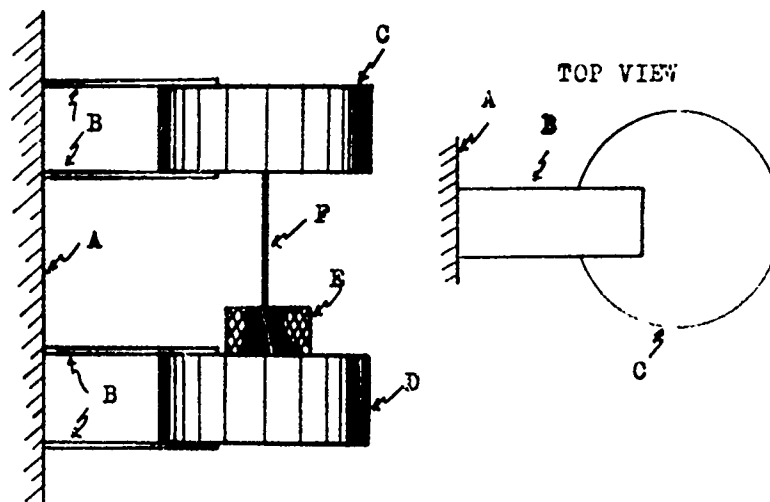


DIAGRAM OF A REMOTE DETONATION

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Fig.5 -  
"Hell" Doppelschwinger

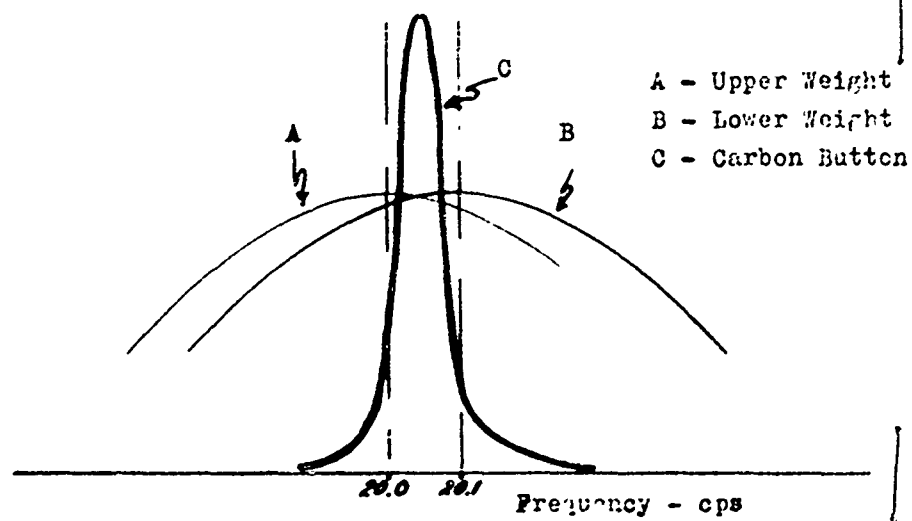


- |                             |                             |
|-----------------------------|-----------------------------|
| A - Mine Case               | D - Lower Weight (20.1 cps) |
| B - Suspension Springs (4)  | E - Carbon Button           |
| C - Upper Weight (20.0 cps) | F - Connecting Rod          |

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Fig.6

Resonance Curves - "Hell" Doppelschwinger



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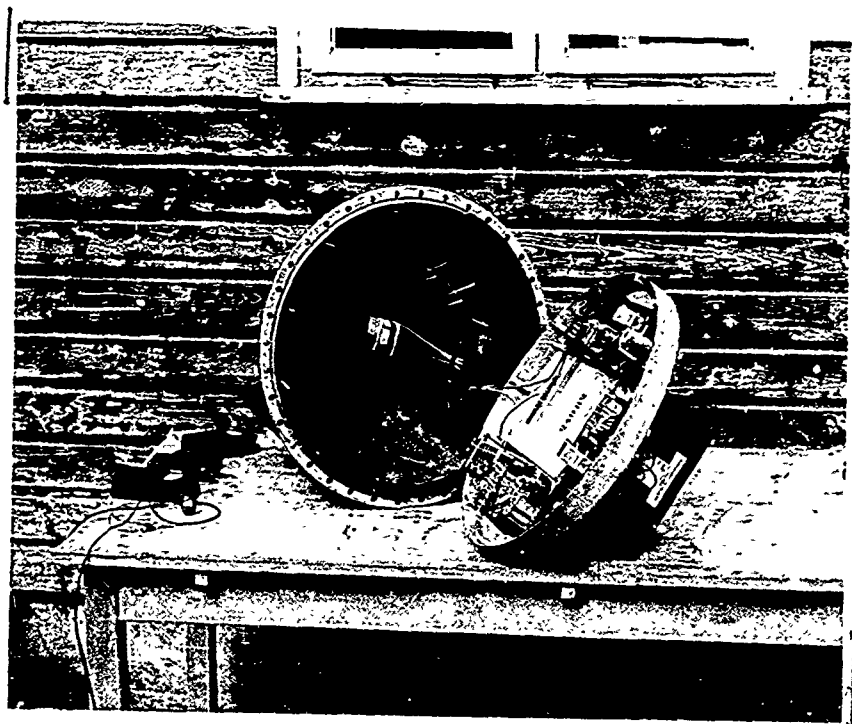


Figure 7

AT 2 Unit Complete - Magnetophone Locked.

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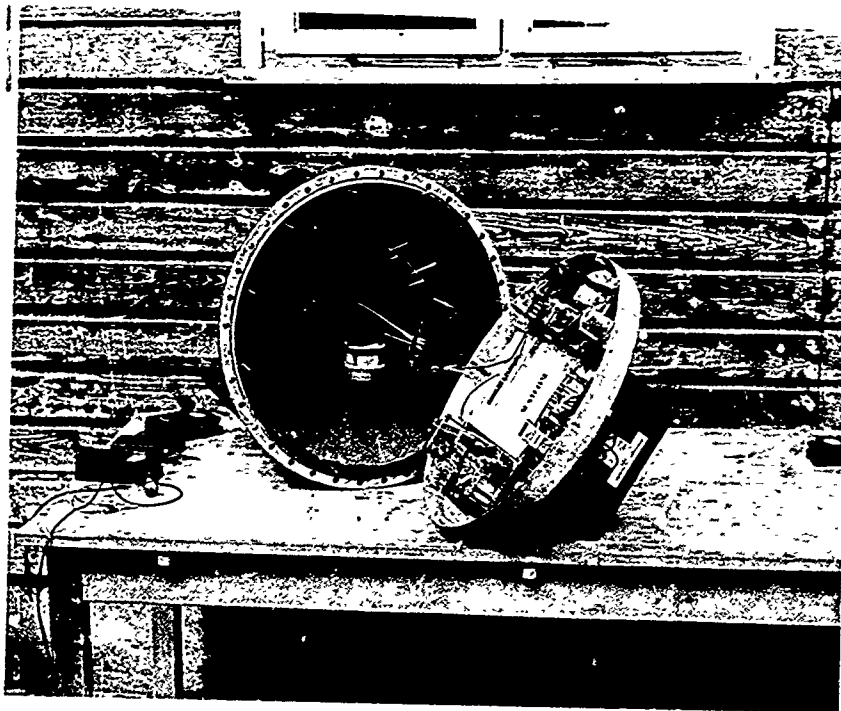


Figure 8

AT 2 Unit Comolete - Magnetophone Unlocked.

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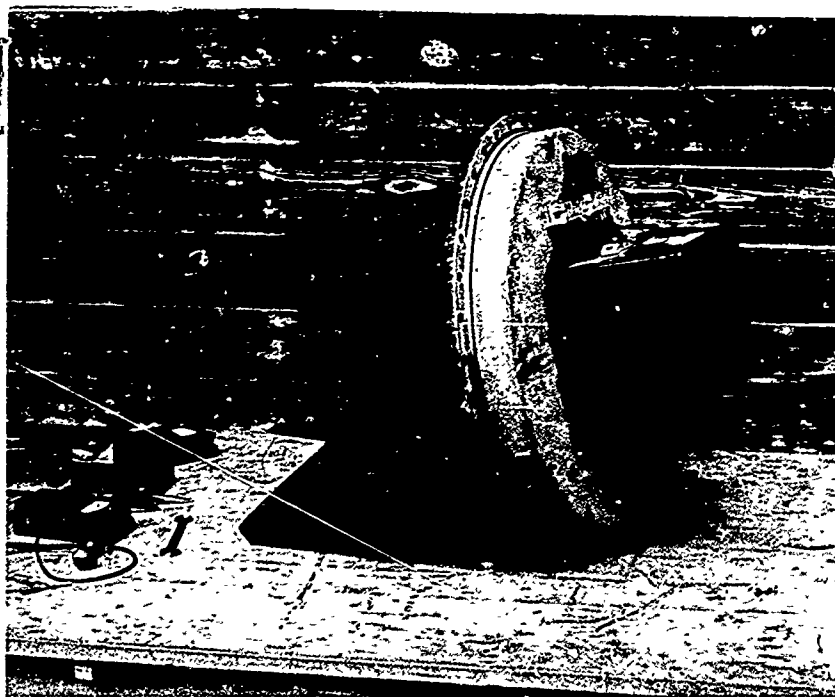


Figure 9

AT 2 Unit Complete and Assembled.

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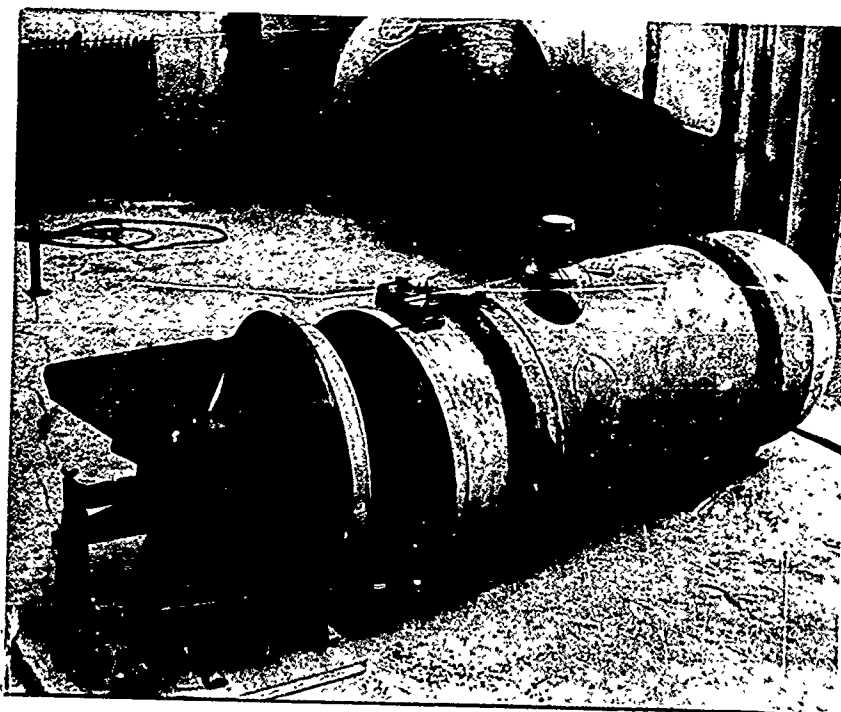


Figure 10

AT 2 Unit Testing Assembly.

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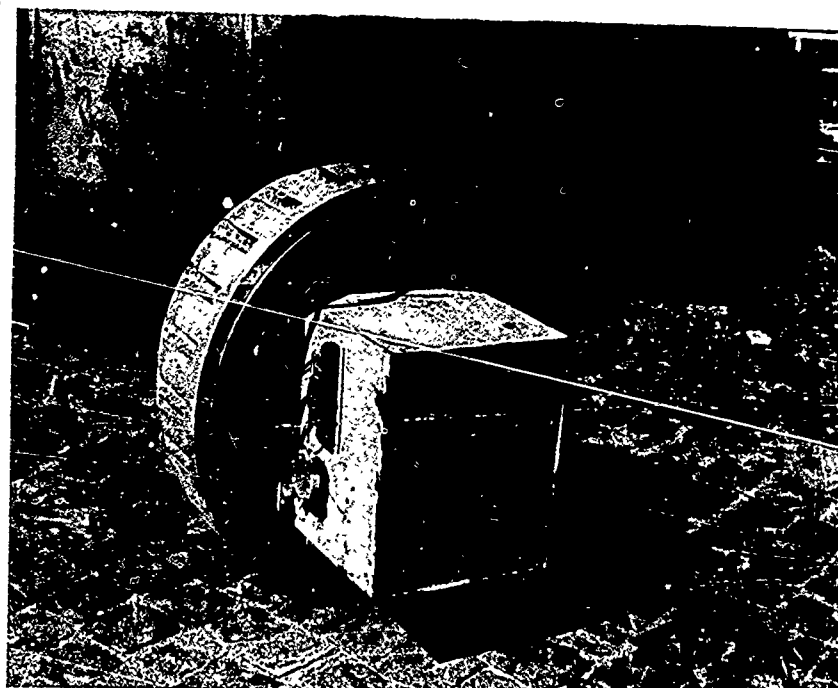


Figure 11

AT 3 Unit Complete

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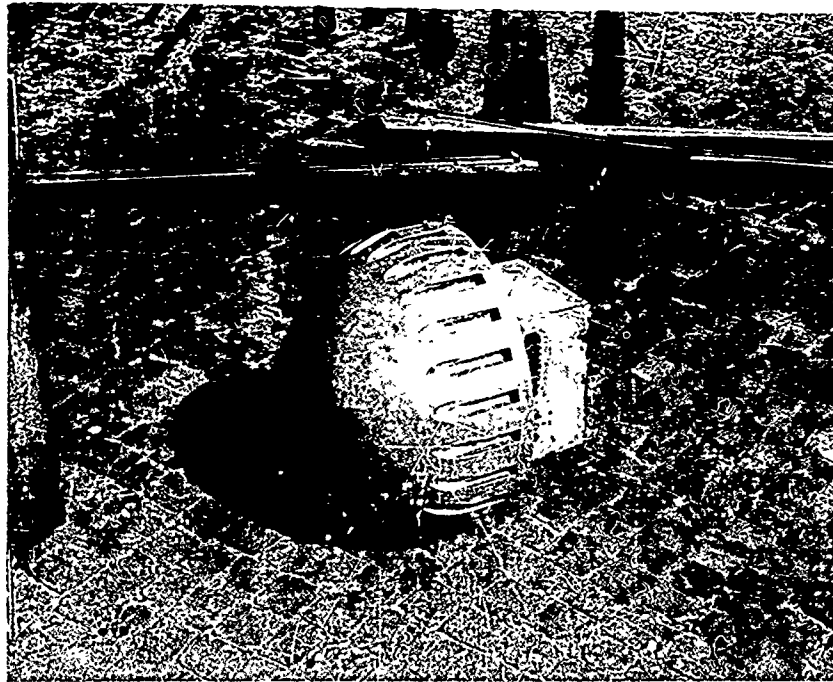


Figure 12

AT 3 Unit Complete.